Black River Watershed Hydrologic Study

Michigan's Nonpoint Source Program

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Table of Contents

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DEQ Michigan's Nonpoint Source Program

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Summary

A hydrologic model of the Black River watershed was developed by the Hydrologic Studies Unit (HSU) of the Michigan Department of Environmental Quality (MDEQ) using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). The hydrologic model was developed to help determine the effect of land use changes on the Black River's flow regime and to provide design flows for streambank stabilization Best Management Practices (BMPs). Watershed stakeholders may combine this information with other determinants, such as open space preservation, to decide what locations are the most appropriate for wetland restoration, stormwater detention, in-stream BMPs, or upland BMPs. Local governments within the watershed could also use the information to help develop stormwater ordinances.

The hydrologic model has two scenarios corresponding to land uses in 1800 and 1978. General land use trends are illustrated in Figure 1. More detailed land use information is provided in Table 1 in the Watershed Description and Model Parameters section of this report.

Because of the land use changes, the model shows increases in runoff volumes and peak flows from 1800 to 1978 for the 50 percent chance (2-year) and 4 percent chance (25-year) 24-hour design storms, as shown in Figures 8 through 11. Additional flow details are in the Model Results section of this report. Increases in the runoff volume and peak flow from the 4 percent chance, 24-hour storms could cause or aggravate flooding problems unless mitigated through the use of effective stormwater management techniques. Increases in the 50 percent chance, 24-hour storm will increase channel-forming flows. The channel-forming flow in a stable stream usually has a one- to two-year recurrence interval. These relatively modest storm flows, because of their higher frequency, have more effect on channel form than extreme flood flows.

Hydrologic changes that increase this flow can cause the stream channel to become unstable. Stream instability is indicated by excessive erosion at many locations throughout a stream reach. Stormwater management techniques used to mitigate flooding can also help mitigate projected channel-forming flow increases. However, channel-forming flow criteria should be specifically considered in the stormwater management plan so that the selected BMPs will be most effective. For example, detention ponds designed to control runoff from the 4 percent chance, 24-hour storm may do little to control the runoff from the 50 percent chance, 24-hour storm, unless the outlet is specifically designed to do so.

One way to compare runoff from different subbasins is to calculate the yield, which is the peak flow divided by the drainage area. The area-weighted average yield from the 50 percent chance (2-year), 24-hour storm for the Black River watershed is 0.006 cubic feet per second per acre (cfs/acre) for 1978 land use scenario. This value may be used to guide stakeholders' fish habitat and stream stability management decisions. The area-weighted average yield from the 4 percent chance (25-year), 24-hour storm for the

Black River watershed is 0.03 cfs/acre for 1978 land use scenario. This value may be used to guide stakeholders' flood control management decisions. Additional details are shown in Figures 12 and 13 and in the Model Results section of this report.

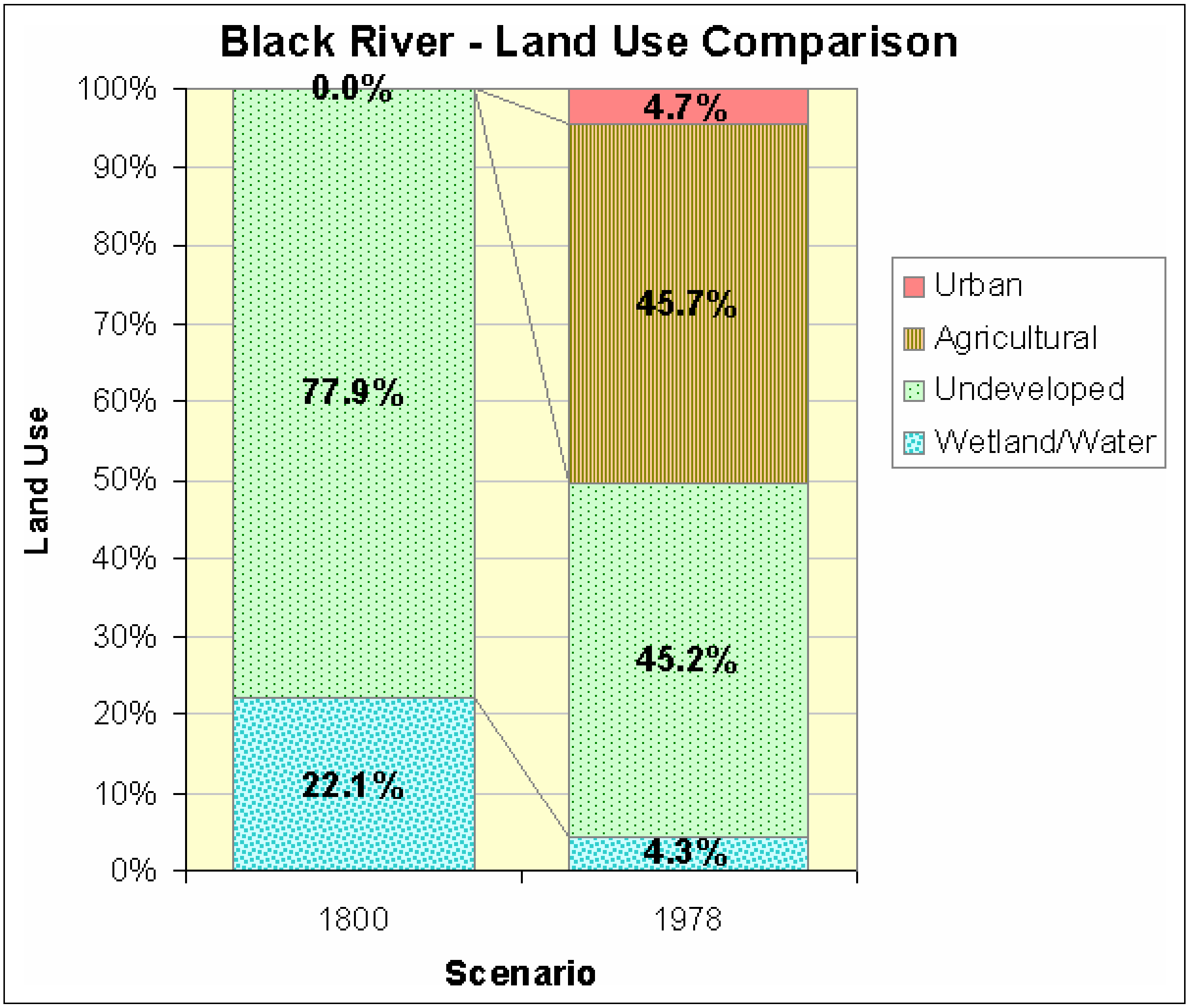


Figure 1: Land Use Comparison

Project Goals

The Black River hydrologic study was initiated in support of the Black River Watershed Planning project, which is funded in part by a United States Environmental Protection Agency (USEPA) Part 319 grant administered by the MDEQ. The goals of this Black River study are:

- To better understand the watershed's hydrologic characteristics and the impact of hydrologic changes in the Black River watershed

- To facilitate the selection and design of suitable BMPs

- To provide information that can be used by local units of government to develop or improve stormwater ordinances

- To help determine the watershed management plan's critical areas – the geographic portions of the watershed contributing the majority of the pollutants and having significant impacts on the waterbody

Watershed Description and Model Parameters

The 286 square mile Black River watershed, Figure 2, outlets to Lake Michigan at South Haven and is located in Allegan and Van Buren counties. Black River's profile, Figure 3, is typical - steeper in the headwaters, flattening out toward the mouth.

This Black River study divides the watershed into 24 subbasins, as shown in Figure 4. Our analysis of the watershed uses the curve number technique to calculate surface runoff volumes and peak flows. This technique, developed by the Natural Resources Conservation Service (NRCS) in 1954, represents the runoff characteristics from the combination of land use and soil data as a runoff curve number. The curve numbers for each subbasin, listed in Appendix A, were calculated from digital soil and land use data using Geographic Information Systems (GIS) technology.

Runoff curve numbers were calculated from the land use and soil data shown in Figures 5 through 7. Land use maps based on the MDEQ GIS data for 1800 and 1978 are shown in Figures 5 and 6, respectively. The 1800 land use information is provided at the request of the Black River project manager. The MDEQ Nonpoint Source program does not expect or recommend that the flow regime calculated from 1800 land use be used as criteria for BMP design or as a goal for watershed managers.

The NRCS soils data for the watershed is shown in Figure 7. Where the soil is given a dual classification, B/D for example, the soil type was selected based on land use. In these cases, the soil type is specified as D for natural land uses or the alternate classification (A, B, or C) for developed land uses. The runoff curve numbers calculated from the soil and land use data are listed in Appendix A. The percent impervious field is left at 0.0, because it is already incorporated in the curve numbers. The initial loss field is left blank so that HEC-HMS uses the default equation based on the curve number. The time of concentration for each subbasin, which is the time it takes for water to travel from the hydraulically most distant point in the watershed to the design point, was calculated from the United States Geological Survey (USGS) quadrangles. The storage coefficients, which represent storage in the subbasin, were iteratively adjusted to provide a peak flow reduction equal to the ponding adjustment factors described further in Appendix A.

The reach routing method is the lag method. Lag is the travel time of water within each section of the stream. The method translates the flood hydrograph through the reach without attenuation. It is not appropriate for reaches that have ponds, lakes, wetlands, or flow restrictions that provide storage and attenuation of floodwater. Lag values for each reach were calculated using USGS quadrangles and are listed in Appendix A.

The selected precipitation events were the 50 and 4 percent chance (2- and 25-year), 24-hour storms. Design rainfall values for these events are tabulated in *Rainfall Frequency Atlas of the Midwest*, Bulletin 71, Midwestern Climate Center, 1992, pp. 126-129, and summarized for this site in Appendix A. These values have been multiplied by 0.914 to account for the size of the watershed.

These parameters were then incorporated into a HEC-HMS model to compute runoff volume and flow.

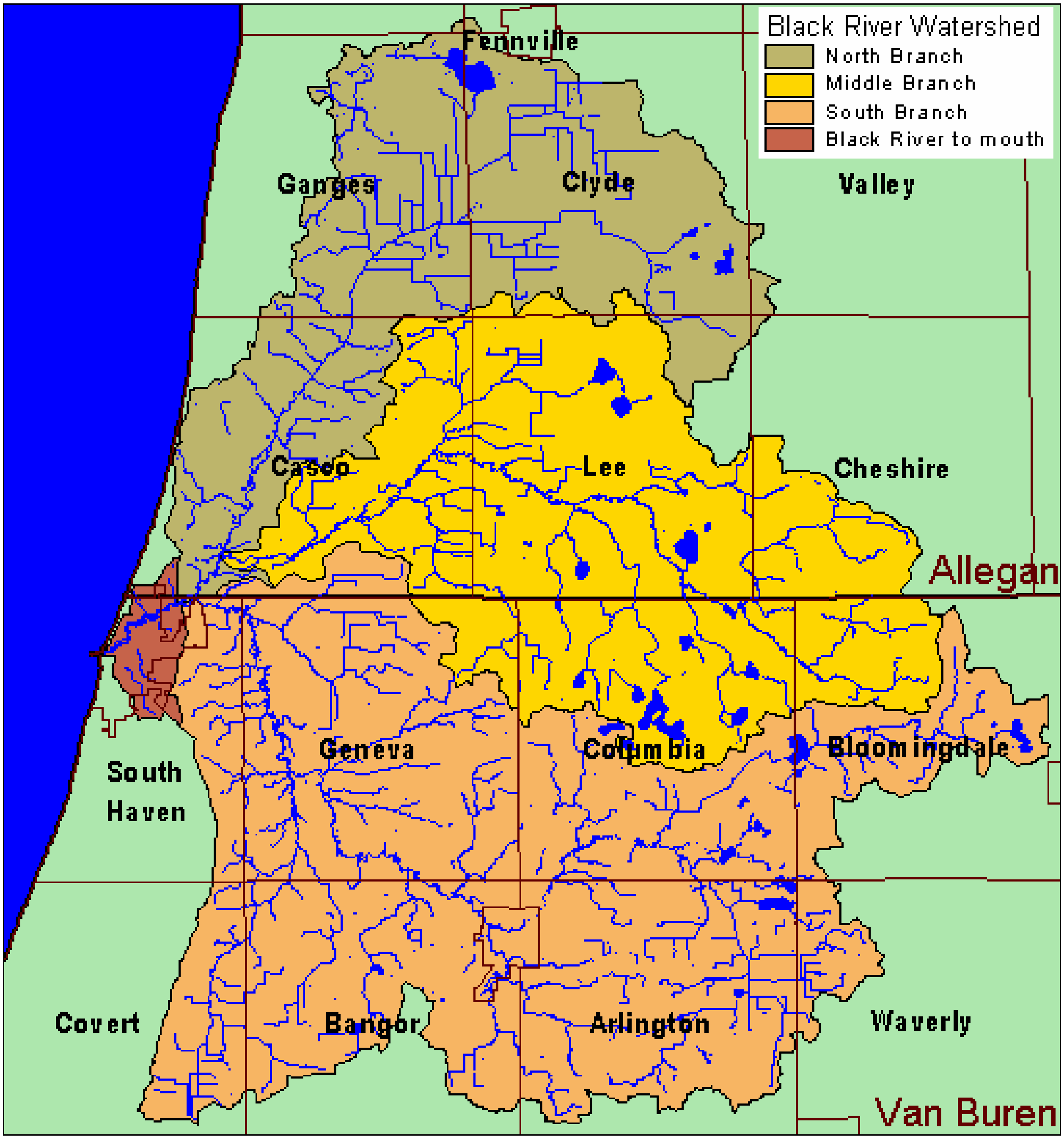


Figure 2: Delineated Black River Watershed

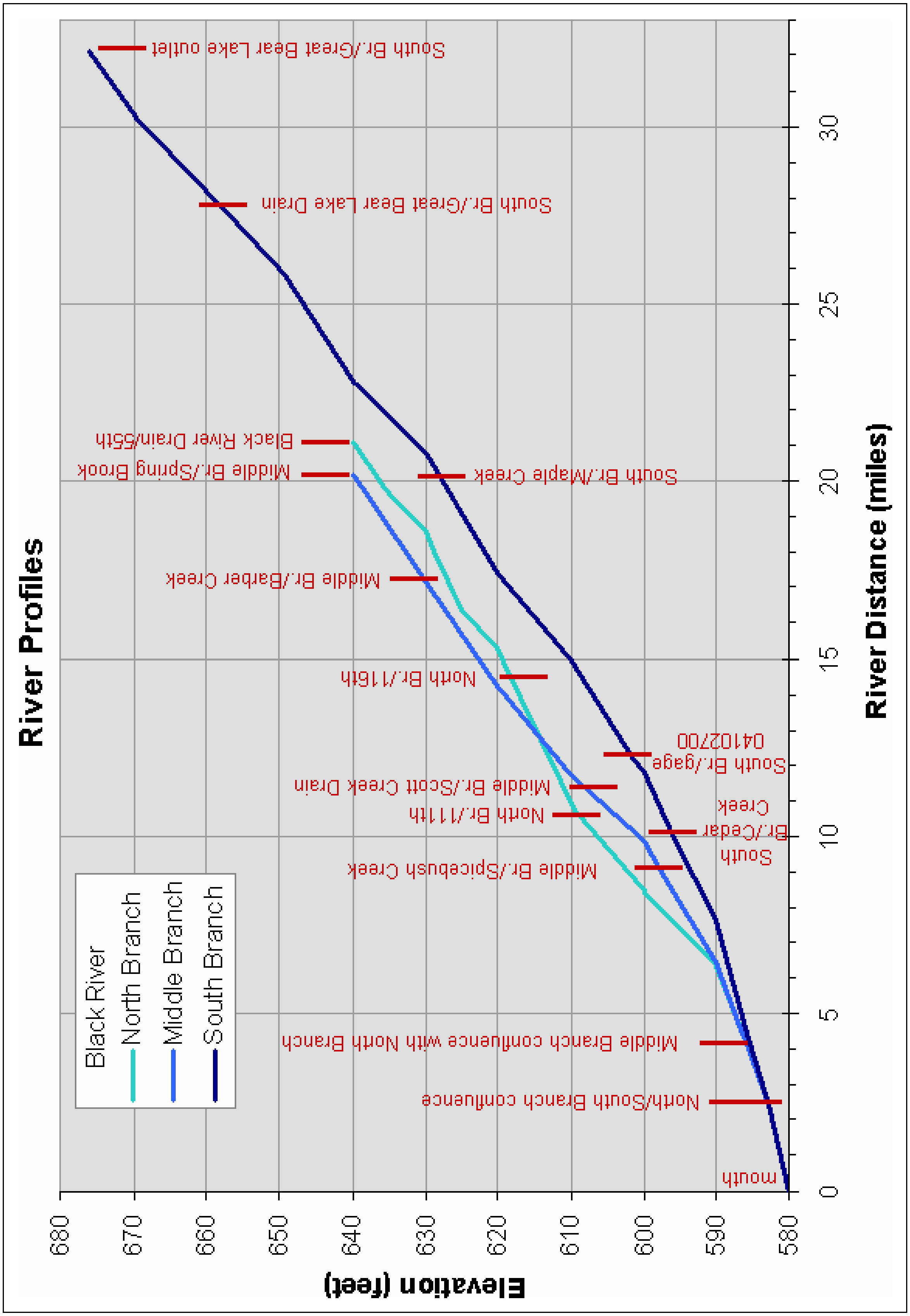


Figure 3: Black River Profile

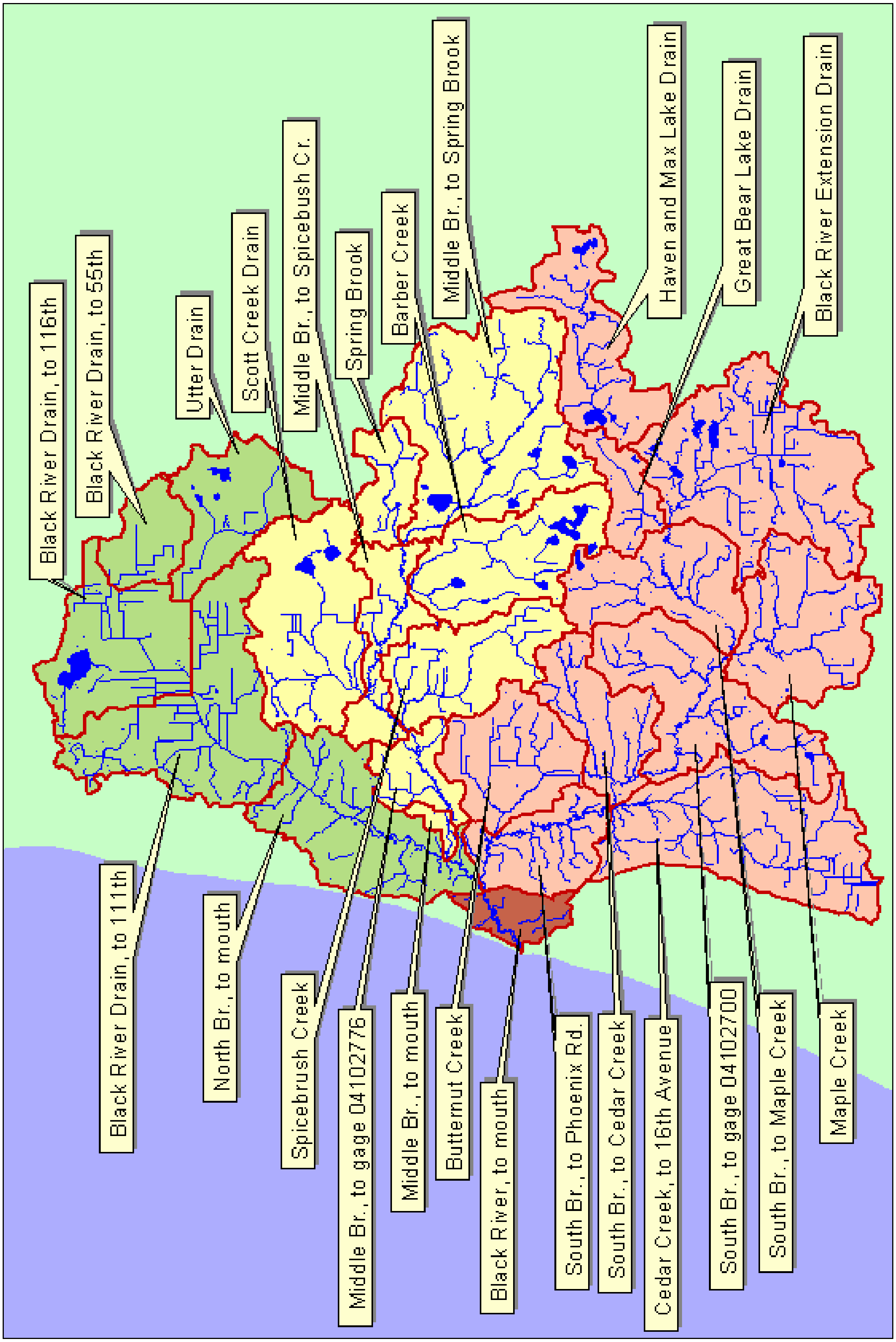


Figure 4: Subbasin Identification

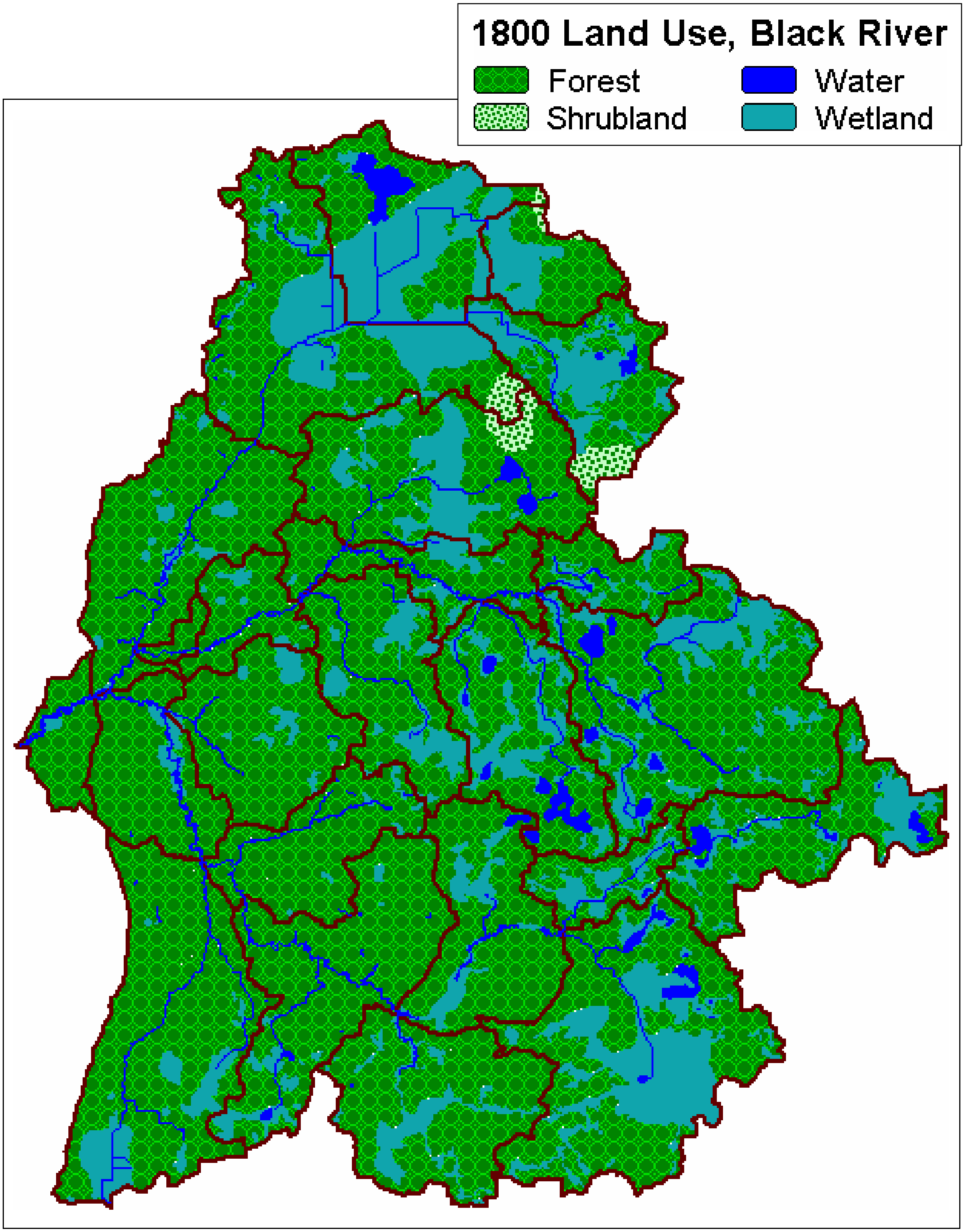


Figure 5: 1800 Land Use Data

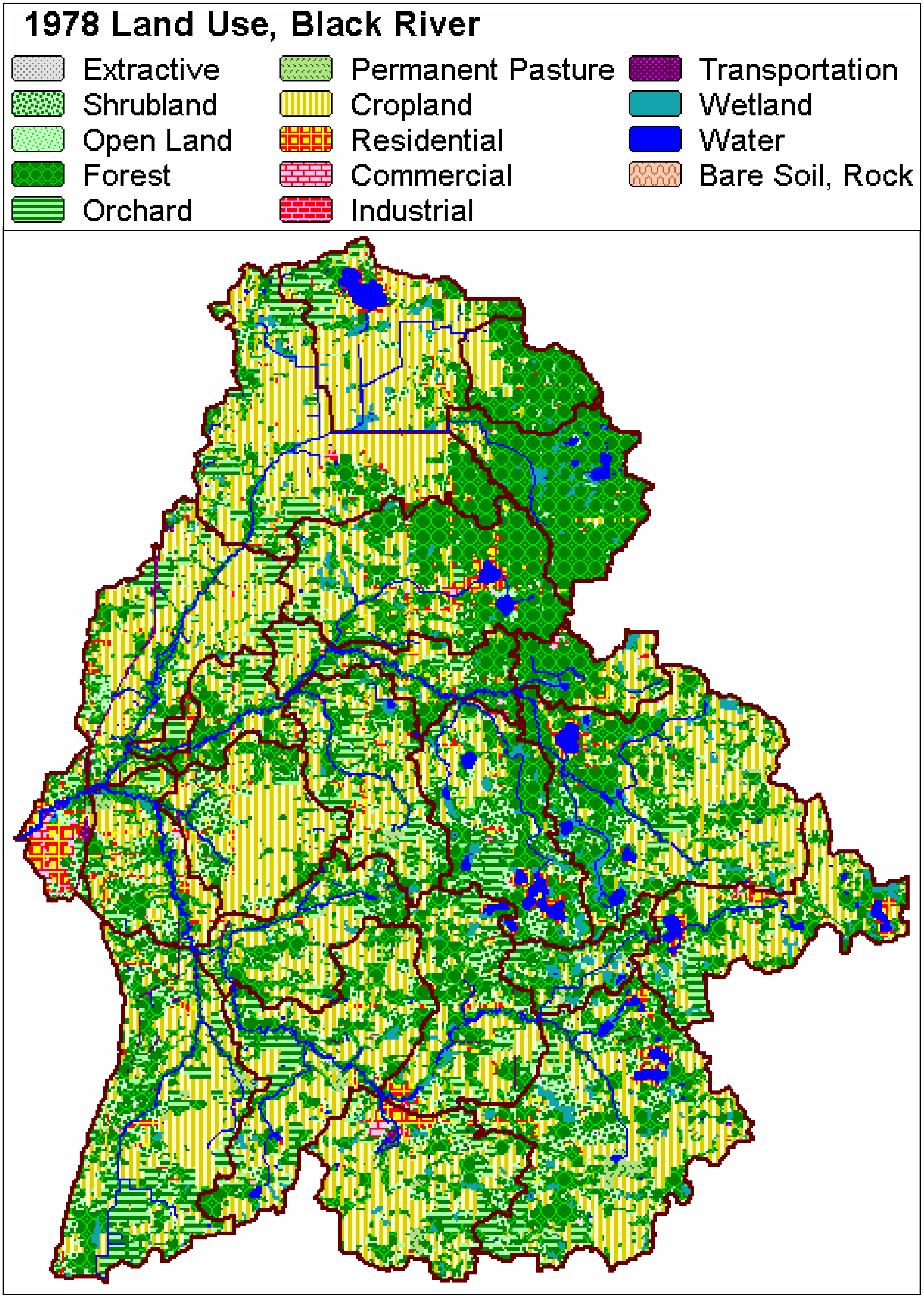


Figure 6: 1978 Land Use Data

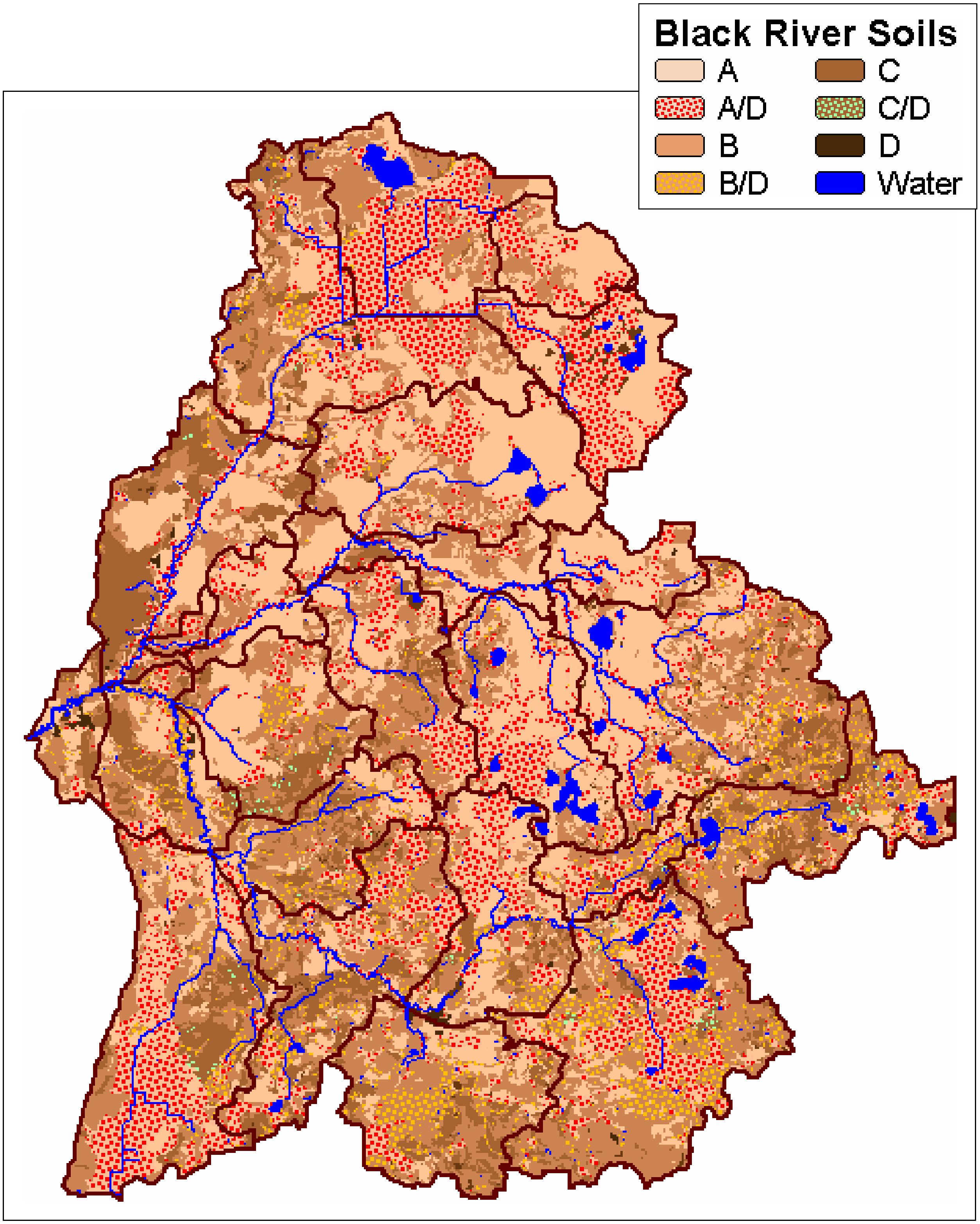


Figure 7: NRCS Soils Data

Table 1: Land Use by Subbasins (Land uses less than 0.5 percent are not listed because all percentages are rounded to the nearest percent)

Description	Scenario	Residential	Commercial	Industrial	Utilities	Gravel Pit	Cemeteries, Outdoor Rec.	Cropland	Orchard	Pasture	Herbaceous Openland	Forest	Water	Wetland
B1	1800											94%	3%	3%
	1978	32%	10%	3%	7%	1%	5%	4%	6%	1%	15%	13%	3%	1%
BM1	1800											100 %		
	1978	9%						18%	26%		7%	40%		
BM2	1800											92%		8%
	1978	3%						30%	13%		6%	46%		1%
BM2SC	1800											80%		20%
	1978	3%						38%	18%	1%	8%	30%		2%
BM3	1800											85%		15%
	1978	3%	1%					26%	11%		5%	51%		1%
BM3aSCD	1800										5%	71%	2%	23%
	1978	6%					1%	23%	6%		4%	55%	2%	3%
BM3bBC	1800											71%	6%	22%
	1978	4%				1%		16%	9%		13%	44%	5%	6%
BM4	1800											75%	3%	22%
	1978	2%						36%	3%	1%	10%	41%	3%	5%
BM4SB	1800											83%	1%	17%
	1978	2%	2%					27%	1%		3%	60%		4%
BN1	1800											94%		6%
	1978	3%			3%		1%	51%	12%		4%	23%		1%
BN2	1800										3%	66%		31%
	1978	2%						54%	11%		4%	25%		2%
BN3	1800										1%	43%	6%	50%
	1978	3%						55%	9%		6%	17%	4%	5%
BN4	1800										10%	52%	2%	37%
	1978	1%						5%			1%	85%	2%	5%
BN4UD	1800										3%	60%		36%
	1978	1%						20%			5%	73%		1%
BS1	1800											91%	1%	8%
	1978	7%	1%		1%			33%	6%	2%	12%	36%		1%
BS1aBC	1800											91%		9%
	1978	3%						58%	4%		11%	22%		
BS2	1800											96%		3%
	1978	1%						40%	4%		10%	42%		2%
BS2CC	1800											87%		13%
	1978	2%			1%			37%	18%	1%	12%	28%		1%
BS3	1800											92%	1%	7%
	1978	1%						42%	12%	1%	7%	33%	1%	2%
BS3MC	1800											84%		15%
	1978	4%	1%		1%			45%	10%	1%	10%	24%		3%

Description	Scenario	Residential	Commercial	Industrial	Utilities	Gravel Pit	Cemeteries, Outdoor Rec.	Cropland	Orchard	Pasture	Herbaceous Openland	Forest	Water	Wetland
BS4	1800											85%	1%	14%
	1978	4%						29%	11%		11%	39%	1%	3%
BS5ed	1800											64%	3%	34%
	1978	3%						34%	8%	2%	15%	32%	2%	3%
BS5GBLD	1800											69%	1%	31%
	1978							19%	7%	3%	18%	42%	1%	10%
BS6GBL	1800											74%	4%	22%
	1978	4%		1%				37%	8%		8%	32%	4%	4%

Model Results

Model results are illustrated in Figures 8 through 17 and detailed in Tables 2 and 3. Table 2 and Figures 8 and 10 show the computed peak flows and runoff volumes from each subbasin. These values represent the peak flow contribution from the subbasins, not the flow in the river. Table 3 and Figures 9 and 11 show the computed peak flows and runoff volumes at locations in the river.

The increases in stormwater runoff volume and peak flows conditions from 1800 to 1978 are due to changes in land use and loss of storage. The hydrologic model shows significant increases in runoff volumes and peak flows for both design storms. Peak flows and runoff volumes from the 50 percent chance 24-hour storm are predicted to increase more, on a percentage basis, than flows from the 4 percent chance, 24-hour storm. Increases in runoff volumes and peak flows from the 50 percent chance storm increase channel-forming flows, which will increase streambank erosion. Channel-forming flow is the flow that is most effective at shaping the channel. In a stable stream, the channel-forming flow has a one- to two-year recurrence interval and is the bankfull flow. Increases in runoff volumes and peak flows from the 4 percent chance storm will aggravate flooding. These projected increases can be moderated through the use of effective stormwater management techniques.

A model stormwater ordinance adopted by nearby Kent County, which is also being considered for adoption by other local units of government, calls for a maximum release rate of 0.05 cfs/acre for runoff from the 50 percent chance, 24-hour storm for Zone A areas, the most environmentally sensitive of the three management zones. Currently, the area-weighted average yield from this storm for the Black River Watershed is 0.006 cfs/acre, with no subbasin greater than 0.012 cfs/acre, as shown in Figure 12. The ordinance also calls for a maximum release rate of 0.13 cfs/acre for runoff from the 4 percent chance, 24-hour storm for Zones A and B. Currently, the average yield from this storm is 0.03 cfs/acre, with no subbasin greater than 0.08 cfs/acre, as shown in Figure 13. Additional details are listed in Table 2. If the Black River watershed stakeholders use the Kent County model ordinance as a basis for a Black River stormwater ordinance, they should consider whether the Kent County model ordinance standards will adequately protect the Black River and its tributaries.

Significant portions of the Black River and its tributaries are designated trout streams, as shown in Figure 14. In our Pigeon River watershed study, we compared the flows from the 50 percent chance, 24-hour storm to flows based on a target yield of 0.0075 cfs/acre. This target yield was selected as criteria for a good trout fishery based on Mike Wiley and Paul Seelbach's November 1998 report titled "*An ecological assessment of opportunities for fisheries rehabilitation in the Pigeon River, Ottawa County*." Although clearly not the sole factor determining fish habitat quality, the good quality trout habitat there corresponds to the locations with yields less than the target yield. Impaired habitat corresponds to locations with yields less than about 1.4 times the target yield. Locations with higher yields generally did not have trout. These same thresholds were applied to the Black River results. For the 1800 scenario, all 17 river locations would be good. For the 1978 scenario, Black River would be impaired above the Great Bear Lake Drain and poor above the Great Bear Lake. Complete results are shown in Figure 15 and listed in Table 9.

The Black River has three main tributaries – the North, Middle, and South Branches. In the Macatawa River watershed, a hydrologic study revealed that the three main tributaries peaked at about the same time (page 8, *A Hydrologic Study of the Macatawa River Watershed*, MDEQ's Hydrologic Studies Unit). A project to alter the timing of one of the three tributaries, and reduce downstream flooding, is in progress. In the Black River, the three tributaries do not peak at the same time, as shown in Figures 16 and 17. Projects that reduce this timing differential have the potential to disproportionately increase peak flows in the main stem of the Black River.

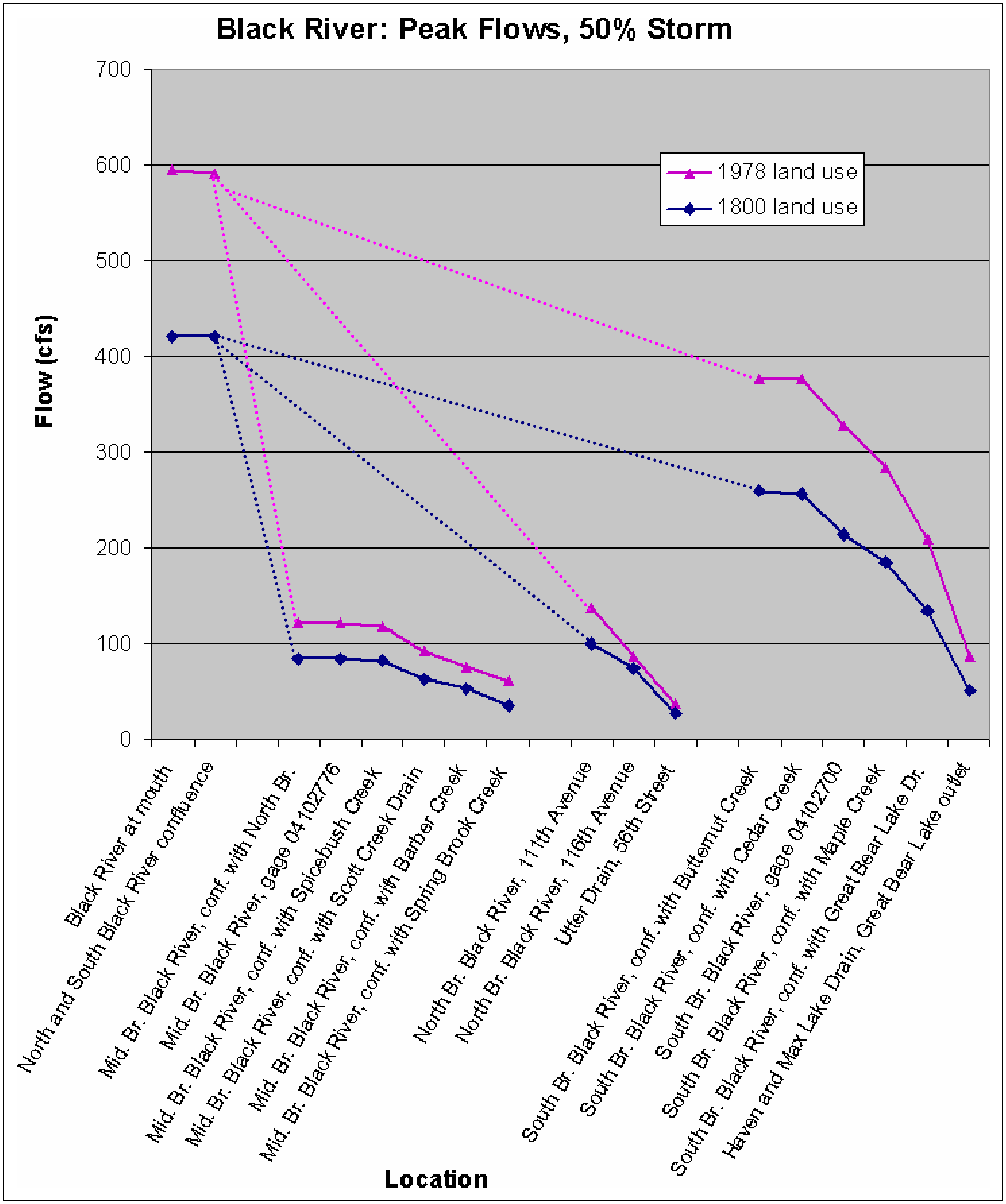


Figure 8: Predicted peak flows for river locations, 50 percent chance storm

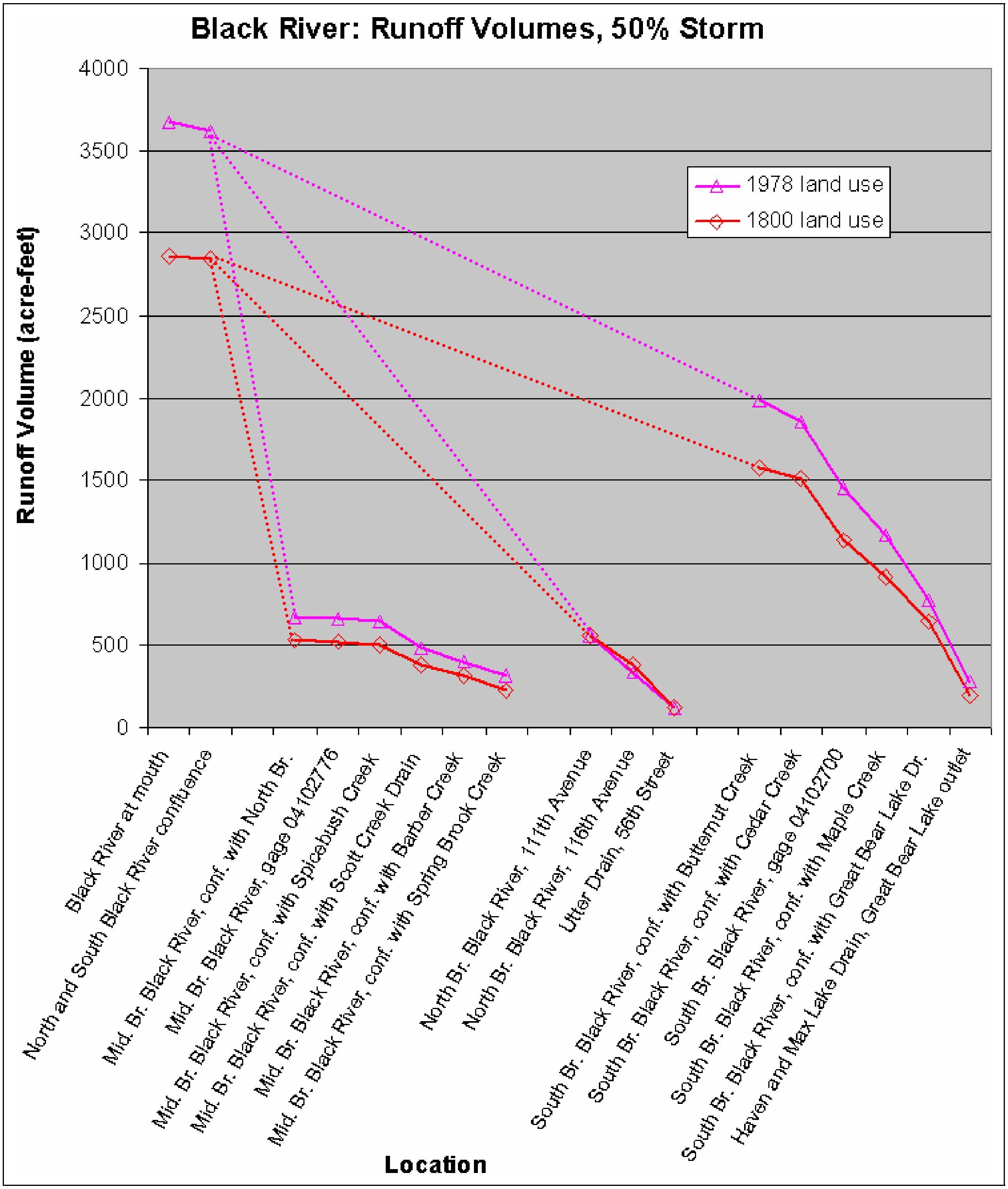


Figure 9: Predicted runoff volumes, 50 percent chance storm

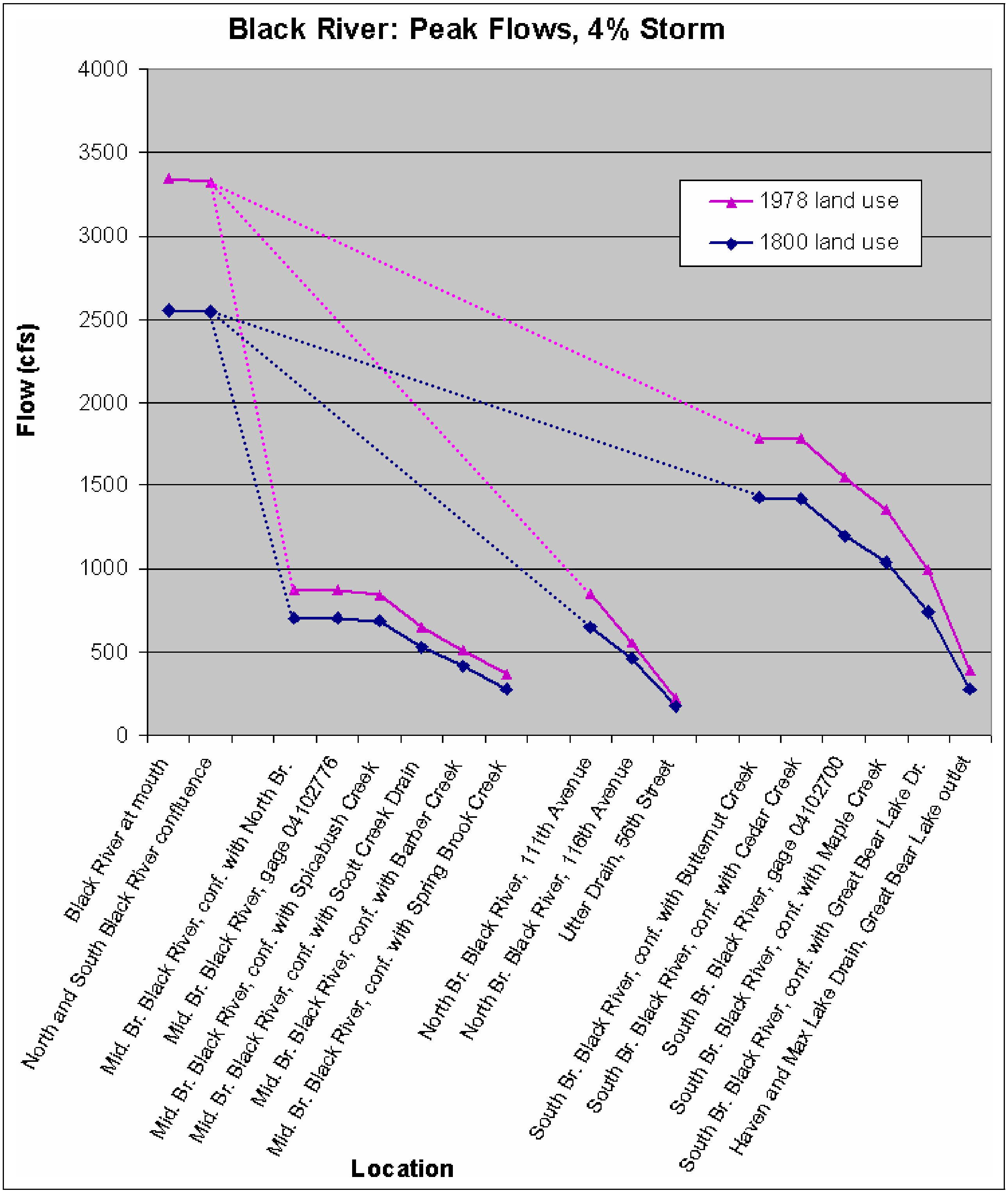


Figure 10: Predicted peak flows for river locations, 4 percent chance storm

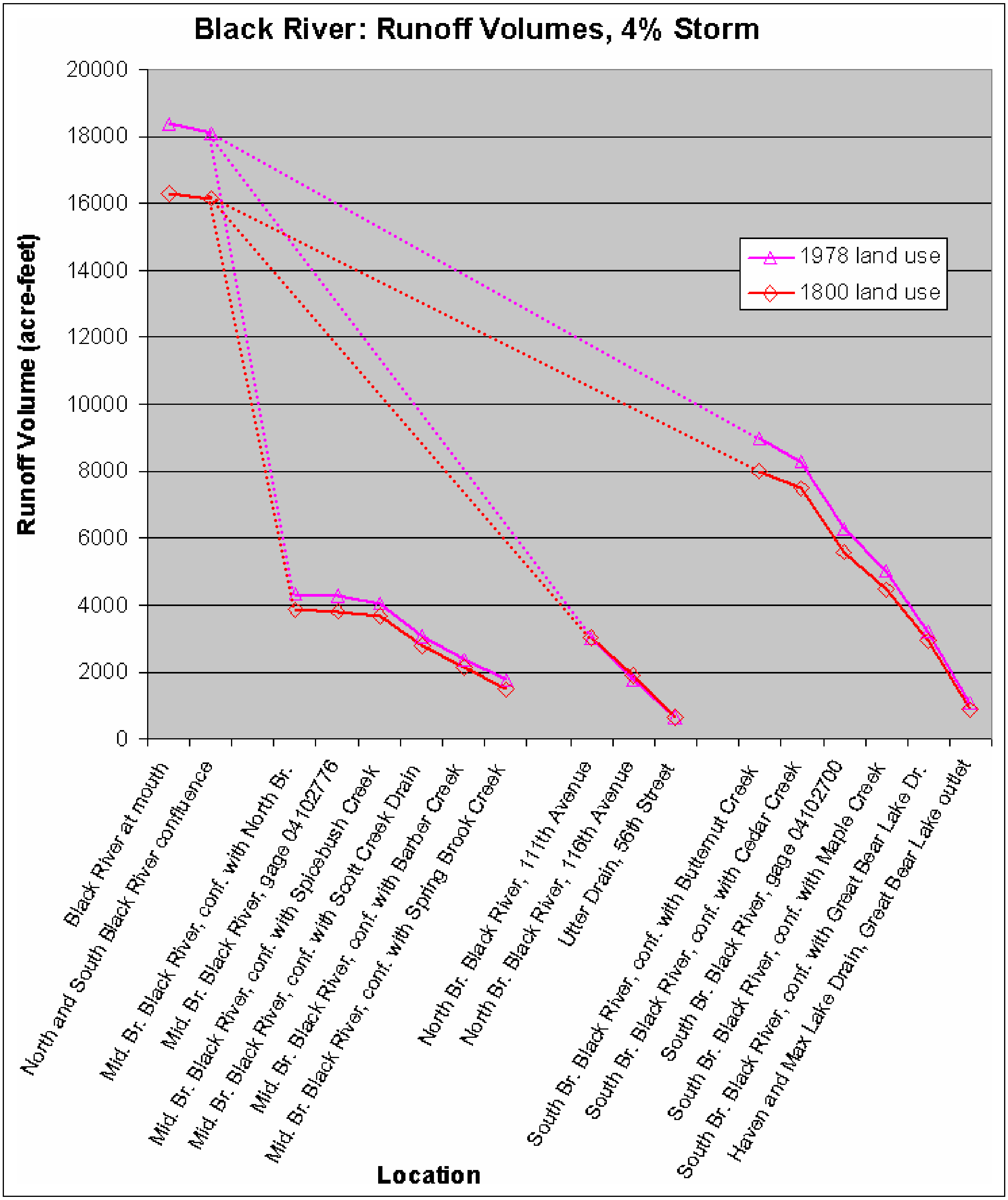


Figure 11: Predicted runoff volumes, 4 percent chance storm

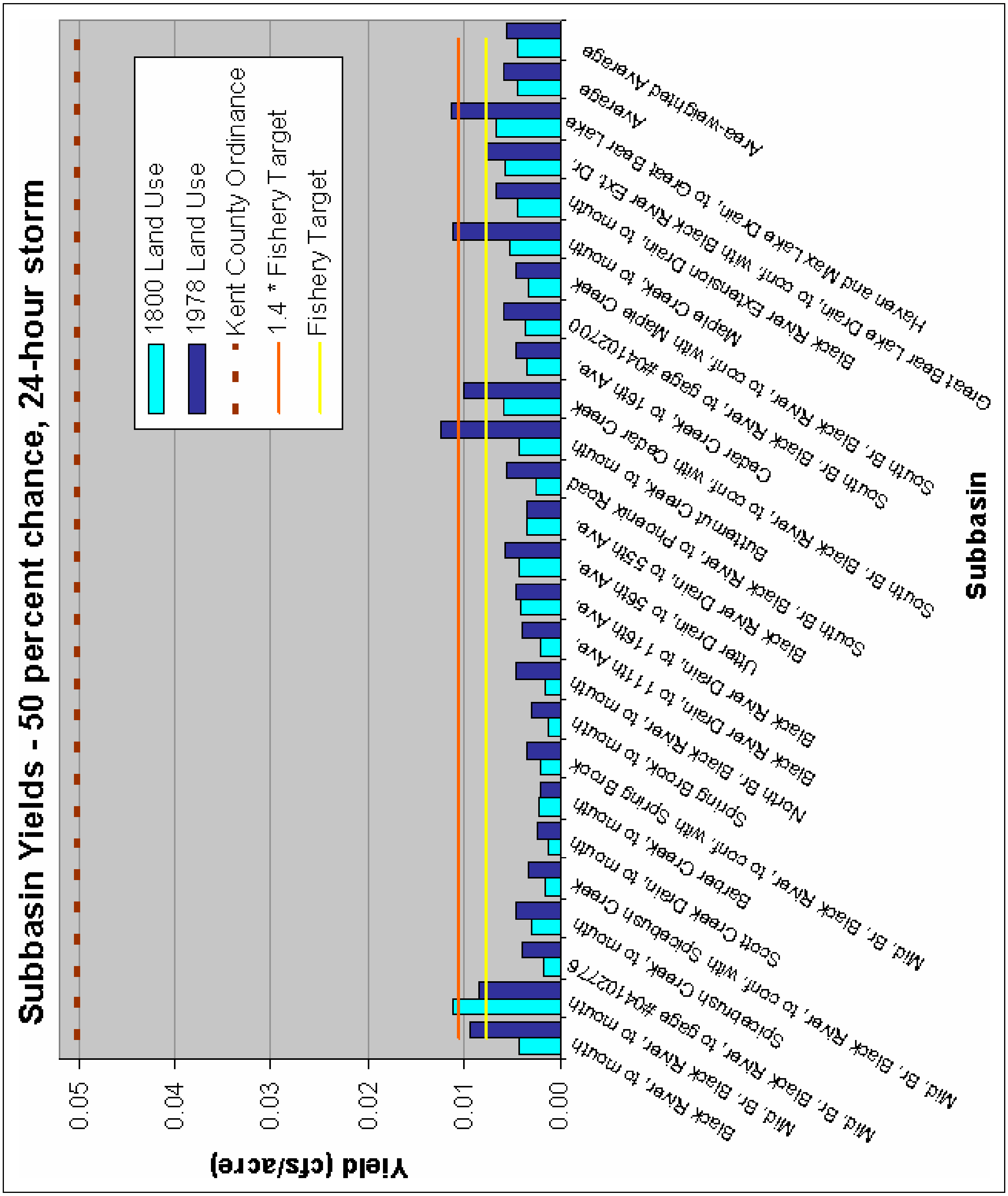


Figure 12: Subbasin Yields, 50 percent chance, 24-hour storm

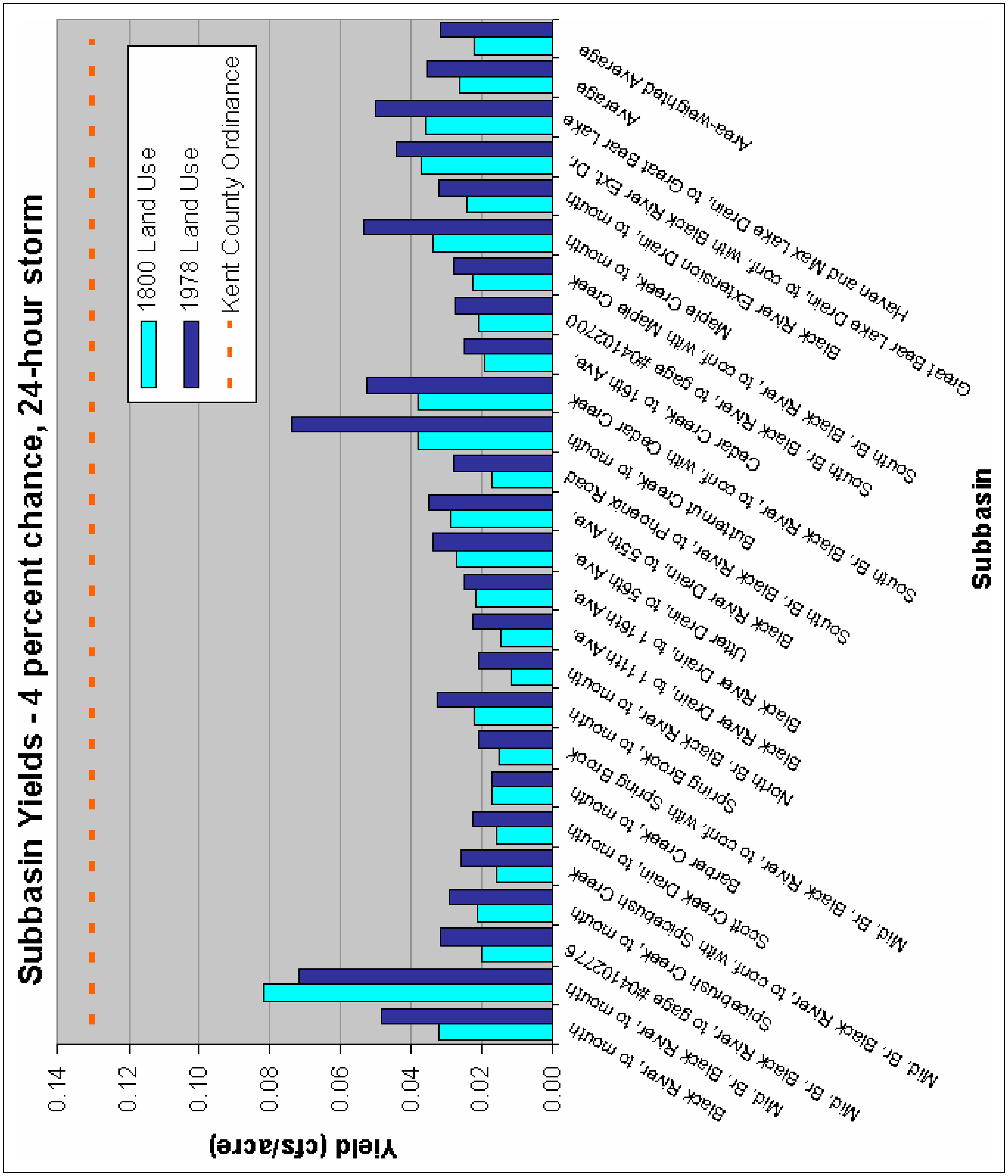


Figure 13: Subbasin Yields, 4 percent chance, 24-hour storm

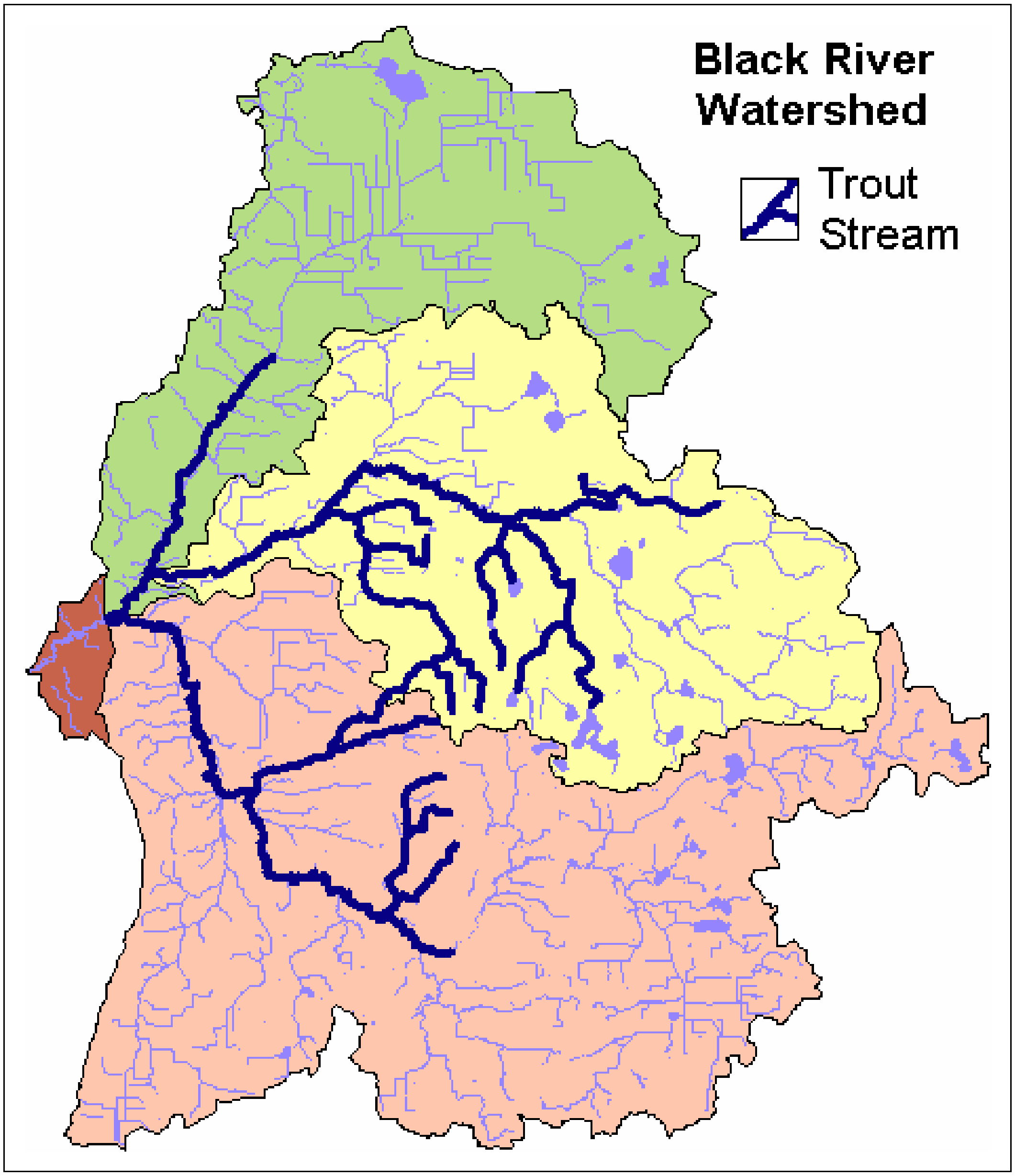


Figure 14: Black River Watershed Trout Streams

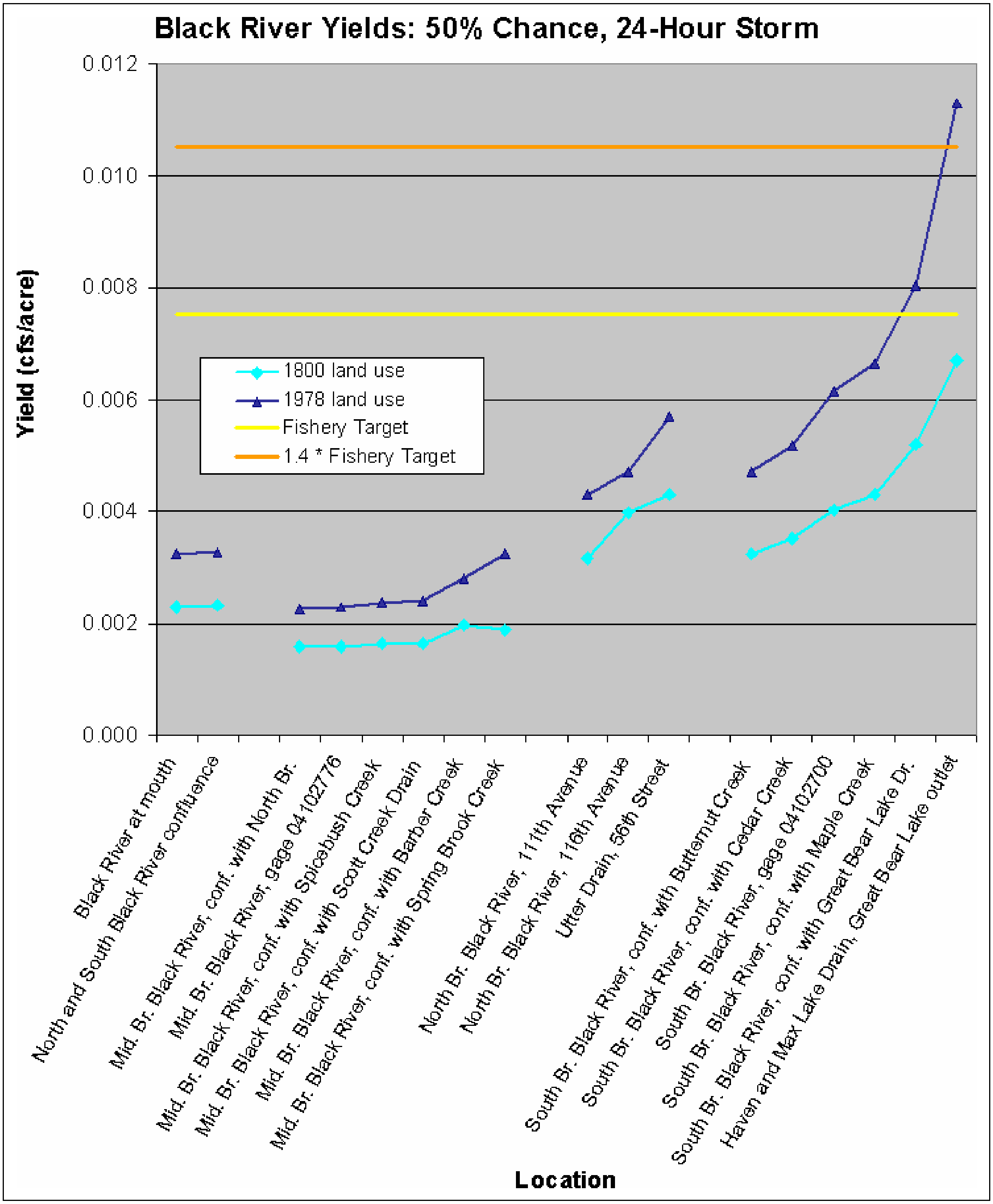


Figure 15: Black River Yields, 50 percent chance, 24-hour storm

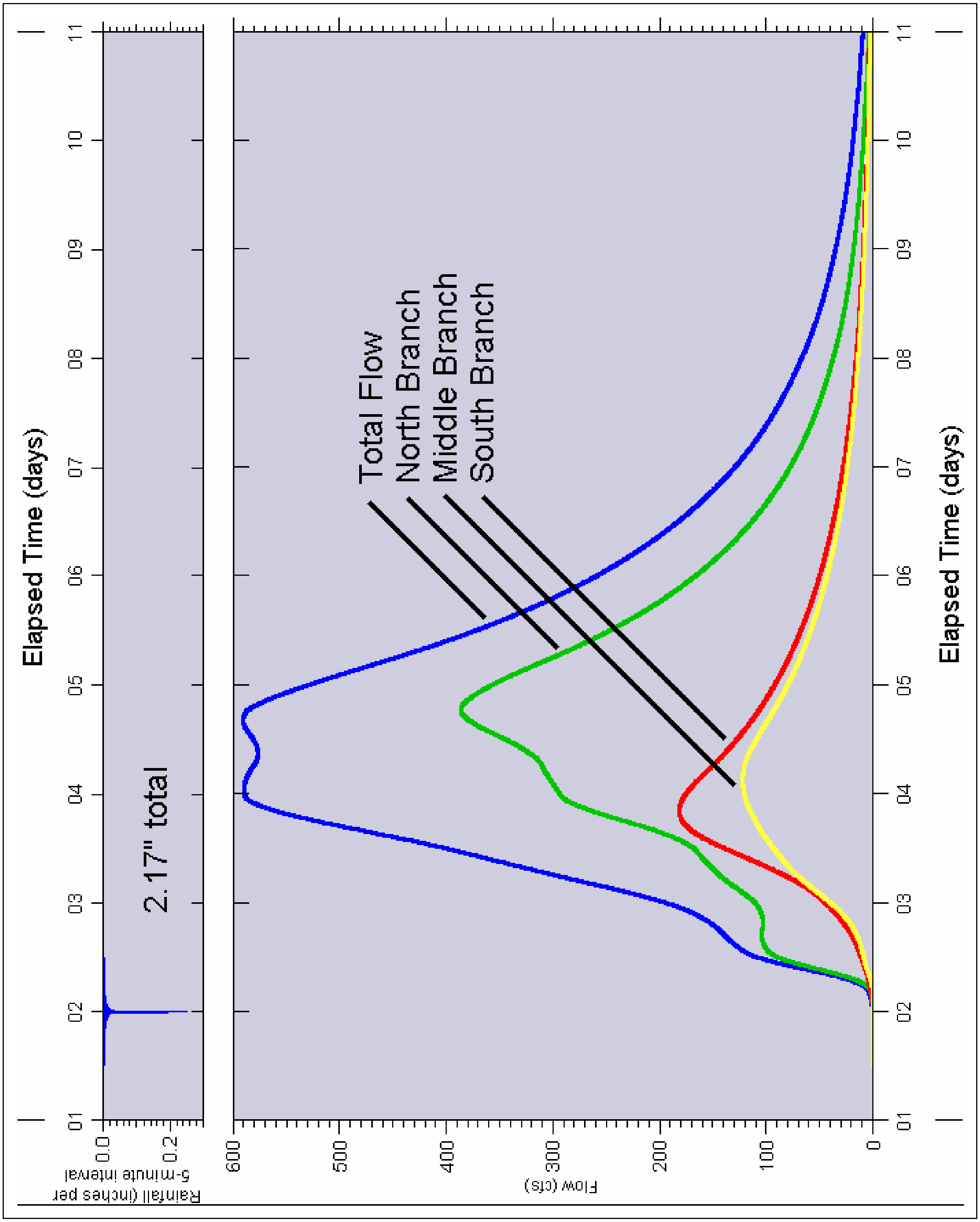


Figure 16: 50 percent chance, 24-hour storm hydrograph for Black River

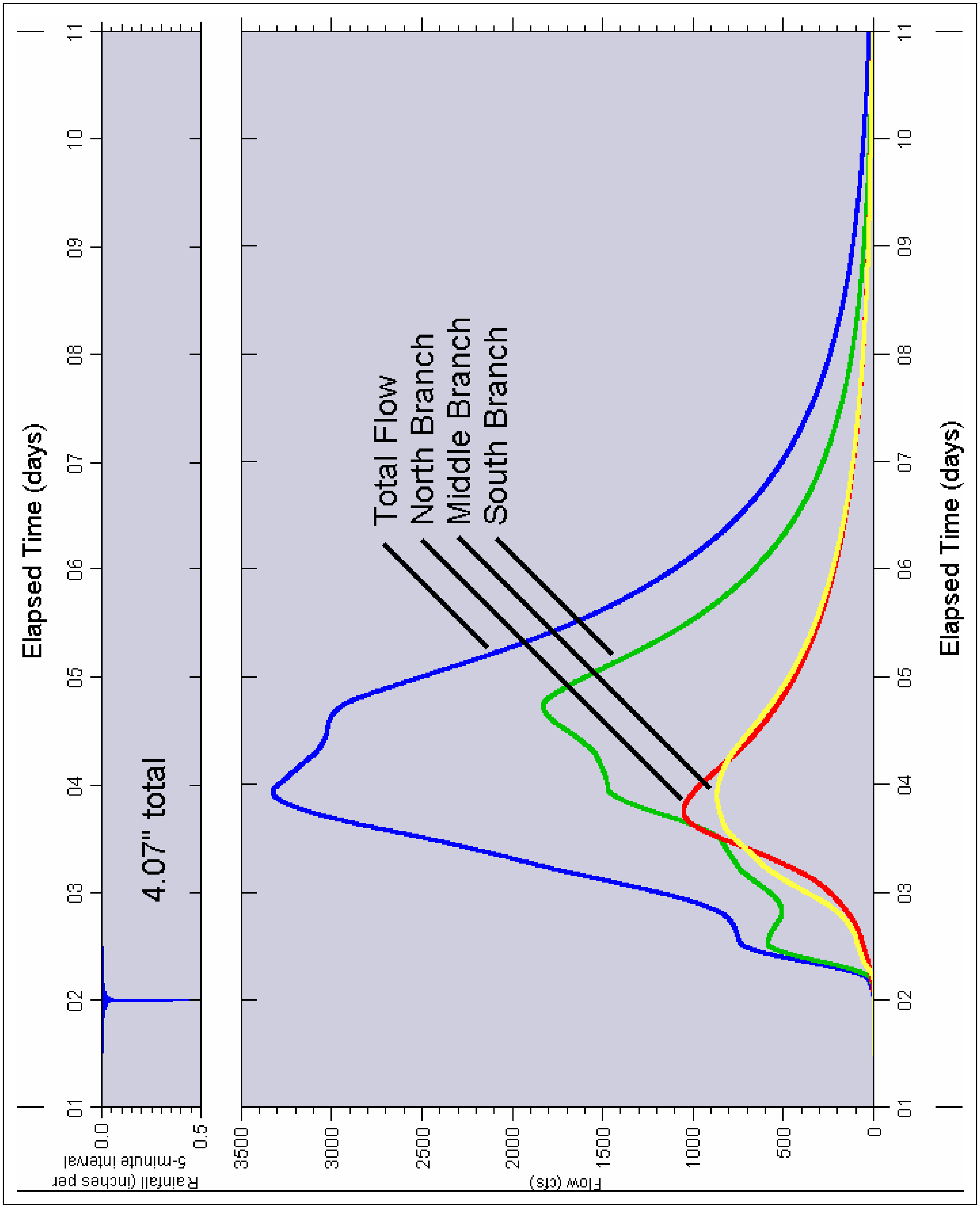


Figure 17: 4 percent chance, 24-hour storm hydrograph for Black River

Table 2: Peak flows and runoff volumes per subbasin

Subbasin			Land Use	Peak Flow (cfs)		Yield (cfs/acre)		Runoff Volume (acre-feet)	
ID	Description	Area (sq. mi.)		50%	4%	50%	4%	50%	4%
B1	Black River, to mouth	3.6	1800	10	75	0.004	0.03	28	186
			1978	22	113	0.009	0.05	60	267
BM1	Mid. Br. Black River, to mouth	0.9	1800	7	49	0.011	0.08	8	50
			1978	5	43	0.008	0.07	6	45
BM2	Mid. Br. Black River, to gage #04102776	4.6	1800	5	59	0.002	0.02	16	169
			1978	11	92	0.004	0.03	27	206
BM2SC	Spicebush Creek, to mouth	11.2	1800	21	151	0.003	0.02	98	606
			1978	33	209	0.005	0.03	110	640
BM3	Mid. Br. Black River, to conf. with Spicebush Creek	7.1	1800	7	72	0.001	0.02	30	284
			1978	16	119	0.003	0.03	48	343
BM3aSCD	Scott Creek Drain, to mouth	17.1	1800	14	174	0.001	0.02	60	637
			1978	26	247	0.002	0.02	85	728
BM3bBC	Barber Creek, to mouth	13.3	1800	19	148	0.002	0.02	101	677
			1978	17	147	0.002	0.02	77	601
BM4	Mid. Br. Black River, to conf. with Spring Brook	24.7	1800	33	239	0.002	0.02	210	1318
			1978	56	326	0.004	0.02	300	1563
BM4SB	Spring Brook, to mouth	4.9	1800	4	70	0.001	0.02	11	158
			1978	10	103	0.003	0.03	21	195
BN1	North Br. Black River, to mouth	16.0	1800	16	116	0.002	0.01	116	786
			1978	47	214	0.005	0.02	283	1217
BN2	Black River Drain, to 111th Ave.	20.6	1800	26	192	0.002	0.01	173	1094
			1978	51	299	0.004	0.02	226	1236
BN3	Black River Drain, to 116th Ave.	13.7	1800	35	189	0.004	0.02	218	995
			1978	40	220	0.005	0.03	185	910
BN4	Utter Drain, to 56th Ave.	10.3	1800	28	178	0.004	0.03	126	650
			1978	37	222	0.006	0.03	126	650
BN4UD	Black River Drain, to 55th Ave.	5.4	1800	12	99	0.003	0.03	41	274
			1978	12	121	0.004	0.04	23	214
BS1	South Br. Black River, to Phoenix Road	8.3	1800	14	92	0.003	0.02	80	469
			1978	29	146	0.006	0.03	124	579
BS1aBC	Butternut Creek, to mouth	10.9	1800	30	263	0.004	0.04	73	523
			1978	86	514	0.012	0.07	133	689
BS2	South Br. Black River, to conf. with Cedar Creek	9.1	1800	34	221	0.006	0.04	89	516
			1978	58	304	0.010	0.05	135	633
BS2CC	Cedar Creek, to 16th Ave.	21.6	1800	48	264	0.003	0.02	287	1426
			1978	64	347	0.005	0.03	264	1367
BS3	South Br. Black River, to gage #04102700	16.4	1800	39	216	0.004	0.02	220	1090
			1978	62	286	0.006	0.03	295	1263
BS4	South Br. Black River, to conf. with Maple Creek	12.0	1800	26	174	0.003	0.02	118	685
			1978	35	215	0.005	0.03	132	723

Subbasin			Land Use	Peak Flow (cfs)		Yield (cfs/acre)		Runoff Volume (acre-feet)	
ID	Description	Area (sq. mi.)		50%	4%	50%	4%	50%	4%
BS4MC	Maple Creek, to mouth	14.1	1800	47	303	0.005	0.03	156	851
			1978	100	481	0.011	0.05	254	1088
BS5ED	Black River Extension Drain, to mouth	24.2	1800	70	373	0.005	0.02	391	1770
			1978	103	500	0.007	0.03	434	1858
BS5GBLD	Great Bear Lake Drain, to conf. with Black River Ext. Dr.	4.4	1800	16	104	0.006	0.04	54	281
			1978	21	126	0.008	0.04	60	295
BS6GBL	Haven and Max Lake Drain, to Great Bear Lake	12.2	1800	52	280	0.007	0.04	200	894
			1978	88	390	0.011	0.05	281	1071
	Average		1800			0.004	0.026		
			1978			0.006	0.036		
	Area-weighted Average		1800			0.004	0.022		
			1978			0.006	0.032		

Table 3: Peak flows and runoff volumes in Black River

River Location			Land Use	Peak Flow (cfs)		Yield (cfs/acre)		Runoff Volume (acre-feet)	
ID	Description	Area (sq. mi.)		50%	4%	50%	4%	50%	4%
J1	Black River at mouth	286	1800	421	2555	0.002	0.014	2864	16281
			1978	594	3340	0.003	0.018	3676	18358
J2	North and South Black River confluence	283	1800	420	2544	0.002	0.014	2847	16126
			1978	591	3325	0.003	0.018	3620	18102
JM1	Mid. Br. Black River, conf. with North Br.	84	1800	84	705	0.002	0.013	528	3883
			1978	122	869	0.002	0.016	671	4313
JM2	Mid. Br. Black River, gage 04102776	83	1800	84	705	0.002	0.013	521	3834
			1978	122	869	0.002	0.016	665	4268
JM3	Mid. Br. Black River, conf. with Spicebush Creek	78	1800	82	684	0.002	0.014	507	3671
			1978	119	846	0.002	0.017	640	4066
JM3a	Mid. Br. Black River, conf. with Scott Creek Drain	60	1800	63	529	0.002	0.014	379	2783
			1978	92	647	0.002	0.017	482	3083
JM3b	Mid. Br. Black River, conf. with Barber Creek	43	1800	53	417	0.002	0.015	321	2151
			1978	77	511	0.003	0.019	398	2358
JM4	Mid. Br. Black River, conf. with Spring Brook Creek	30	1800	36	279	0.002	0.015	221	1476
			1978	61	375	0.003	0.020	321	1758
JN2	North Br. Black River, 111th Avenue	50	1800	100	654	0.003	0.020	557	3011
			1978	138	853	0.004	0.027	560	3011
JN3	North Br. Black River, 116th Avenue	29	1800	74	464	0.004	0.025	385	1919
			1978	88	561	0.005	0.030	333	1775
JN4a	Upper Black River Drain, 55th Street	5	1800	12	99	0.003	0.029	41	274
			1978	12	121	0.004	0.035	23	214
JN4b	Utter Drain, 56th Street	10	1800	28	178	0.004	0.027	126	650
			1978	37	222	0.006	0.034	126	650
JS1	South Br. Black River, conf. with Butternut Creek	125	1800	260	1430	0.003	0.018	1574	8003
			1978	376	1783	0.005	0.022	1986	8986
JS2	South Br. Black River, conf. with Cedar Creek	114	1800	257	1420	0.004	0.019	1509	7499
			1978	376	1783	0.005	0.024	1855	8298
JS3	South Br. Black River, gage 04102700	83	1800	214	1198	0.004	0.022	1135	5560
			1978	329	1549	0.006	0.029	1455	6297
JS4	South Br. Black River, conf. with Maple Creek	67	1800	184	1040	0.004	0.024	917	4476
			1978	284	1355	0.007	0.032	1161	5034
JS5	South Br. Black River, conf. with Great Bear Lake Dr.	41	1800	135	739	0.005	0.028	645	2945
			1978	209	993	0.008	0.038	775	3224
JS6	Haven and Max Lake Drain, Great Bear Lake outlet	12	1800	52	280	0.007	0.036	200	894
			1978	88	390	0.011	0.050	281	1071

Appendix

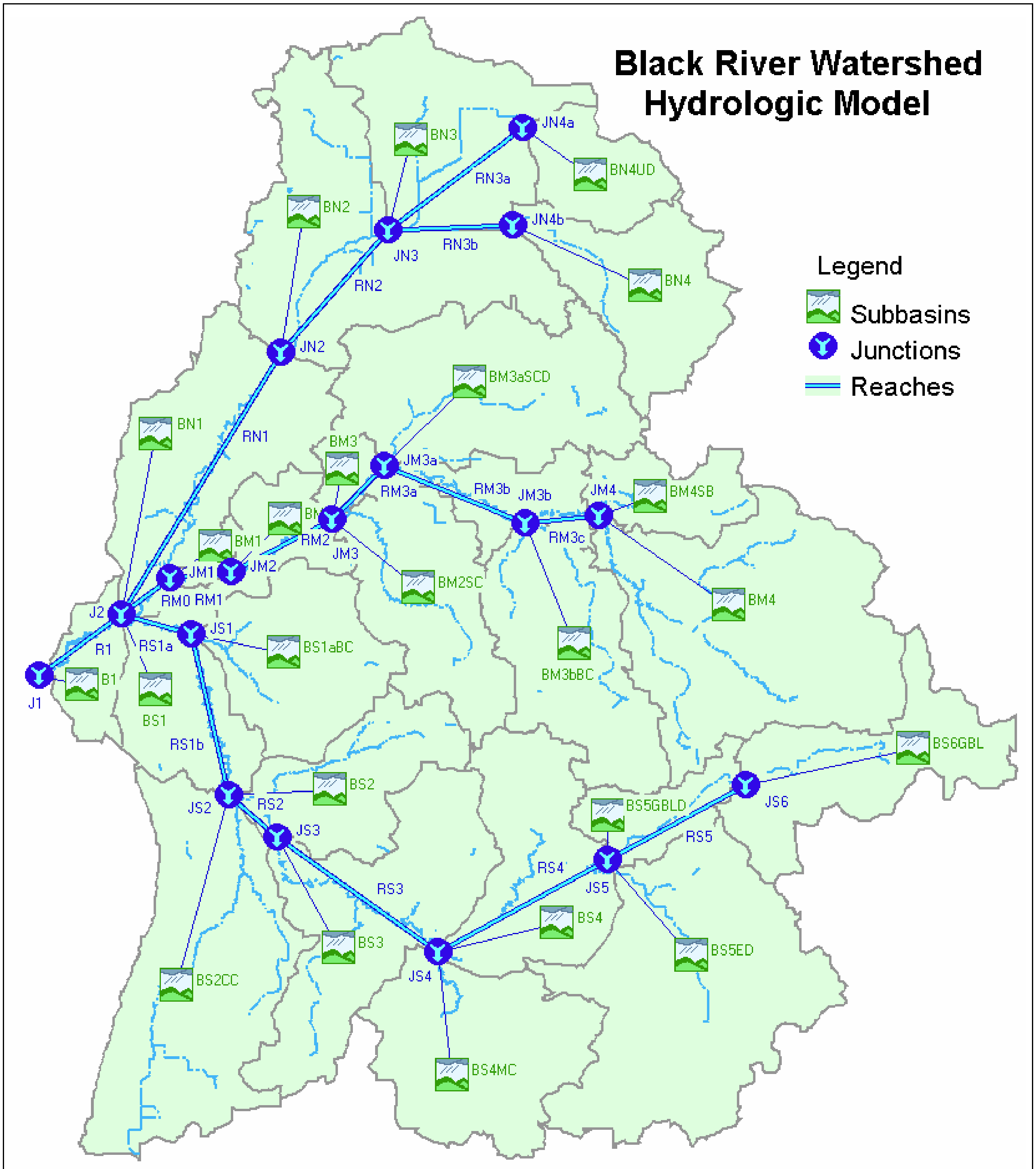
Appendix A: Black River Hydrologic Model Parameters

This appendix is provided so that the model may be recreated. Table A1 provides the design rainfall values specific to the region of the state where the Black River is located. Figure A1 summarizes the hydrologic elements in the HEC-HMS model. Tables A2 and A3 provide the parameters that were specified for each of these hydrologic elements. The initial loss field in HEC-HMS is left blank so that the default equation based on the curve number is used. Table A4 provides the reach parameters for the lag routing method. HEC-HMS was run for a ten-day duration using a five-minute computation interval.

Table A1: Design Rainfall Values

SCS Type II Precipitation Event	Precipitation	Area-adjusted Precipitation*
50% chance (2-year), 24-hour storm	2.37 inches	2.17 inches
4% chance (25-year), 24-hour storm	4.45 inches	4.07 inches

*standard values were multiplied by 0.914 to account for the watershed size



B1, Black River, to mouth
BM1, Mid. Br. Black River, to mouth
BM2, Mid. Br. Black River, to gage #04102776
BM2SC, Spicebrush Creek, to mouth
BM3, Mid. Br. Black River, to conf. with Spicebush Creek
BM3aSCD, Scott Creek Drain, to mouth
BM3bBC, Barber Creek, to mouth
BM4, Mid. Br. Black River, to conf. with Spring Brook
BM4SB, Spring Brook, to mouth
BN1, North Br. Black River, to mouth
BN2, Black River Drain, to 111th Ave.
BN3, Black River Drain, to 116th Ave.
BN4, Utter Drain, to 56th Ave.
BN4UD, Black River Drain, to 55th Ave.
BS1, South Br. Black River, to Phoenix Road
BS1aBC, Butternut Creek, to mouth
BS2, South Br. Black River, to conf. with Cedar Creek
BS2CC, Cedar Creek, to 16th Ave.
BS3, South Br. Black River, to gage #04102700
BS4, South Br. Black River, to conf. with Maple Creek
BS4MC, Maple Creek, to mouth
BS5ED, Black River Extension Drain, to mouth
BS5GBLD, Great Bear Lake Drain, to conf. with Black River Ext. Dr.
BS6GBL, Haven and Max Lake Drain, to Great Bear Lake

Figure A1: Hydrologic Elements defined for HEC-HMS model

Table A2: Subbasin Parameters – Area, Curve Number, Initial Loss

Subbasins ID	Subbasins Description	Drainage Area (sq. mi.)	Runoff Curve Number 1800	Runoff Curve Number 1978	Initial Loss
B1	Black River to mouth	3.64	63	70	
BM1	Middle Branch Black River to mouth	0.93	64	62	Default
BM2	Middle Branch Black River at gage #04102776	4.56	58	61	Default
BM2SC	Spicebush Creek to mouth	11.23	64	65	Default
BM3	Middle Branch Black River at confluence with Spicebush Creek	7.14	59	62	Default
BM3aSCD	Scott Creek Drain to mouth	17.14	58	60	Default
BM3bBC	Barber Creek to mouth	13.28	63	61	Default
BM4	Middle Branch Black River to confluence with Spring Brook	24.70	64	67	Default
BM4SB	Spring Brook to mouth	4.91	56	59	Default
BN1	North Branch Black River to mouth	15.96	63	71	Default
BN2	Black River Drain to 111th Avenue	20.55	64	66	Default
BN3	Black River Drain to 116th Avenue	13.66	70	68	Default
BN4	Utter Drain to 56th Avenue	10.26	67	67	Default
BN4UD	Black River Drain to 55th Avenue	5.38	63	59	Default
BS1	South Branch Black River to Phoenix Road	8.27	65	69	Default
BS1aBC	Butternut Creek to mouth	10.87	62	67	Default
BS2	South Branch Black River to confluence with Cedar Creek	9.05	65	69	Default
BS2CC	Cedar Creek to 16th Avenue, gage #04102720	21.58	68	67	Default
BS3	South Branch Black River to Gage #04102700	16.42	68	71	Default
BS4	South Branch Black River to confluence with Maple Creek	12.01	65	66	Default
BS4MC	Maple Creek to mouth	14.14	66	71	Default
BS5ed	Black River Extension Drain to mouth	24.16	70	71	Default
BS5GBLD	Great Bear Lake Drain to confluence with Black River Extension Drain	4.43	67	68	Default
BS6GBL	Haven and Max Lake Drain to Great Bear Lake	12.18	70	74	Default
	Total	286			

Table A3: Subbasin Parameters – Times of Concentration and Storage Coefficients

Subbasin ID	Land Use Scenario	Time of Concentration (hours)	Storage Coefficient	
			50% chance, 24-hour storm	4% chance, 24-hour storm
B1	1800	11.18	23.41	19.03
	1978		21.52	18.03
BM1	1800	5.35	5.35	5.35
	1978		5.35	5.35
BM2	1800	12.53	27.61	22.86
	1978		17.72	15.99
BM2SC	1800	17.18	43.30	35.40
	1978		27.21	24.43
BM3	1800	17.33	40.97	34.23
	1978		24.36	22.21
BM3aSCD	1800	14.48	39.35	31.66
	1978		27.59	23.55
BM3bBC	1800	18.95	51.28	41.44
	1978		42.29	35.68
BM4	1800	24.39	62.28	51.51
	1978		49.19	42.41
BM4SB	1800	7.64	22.19	16.65
	1978		16.53	12.80
BN1	1800	37.51	72.77	63.45
	1978		51.83	48.03
BN2	1800	24.40	65.81	53.76
	1978		38.01	34.64
BN3	1800	20.03	63.21	49.65
	1978		42.17	36.15
BN4	1800	13.58	41.29	31.97
	1978		28.53	23.77
BN4UD	1800	9.38	31.23	22.56
	1978		12.44	11.19
BS1	1800	25.45	53.09	45.74
	1978		34.58	32.13
BS1aBC	1800	7.37	19.25	13.91
	1978		8.73	8.00
BS2	1800	11.03	20.61	17.51
	1978		17.14	14.96
BS2CC	1800	25.98	57.45	49.38
	1978		33.77	31.72
BS3	1800	25.86	52.01	45.08
	1978		40.92	37.40
BS4	1800	17.52	40.94	34.26
	1978		31.88	27.83
BS4MC	1800	11.30	28.41	22.70
	1978		19.56	16.95
BS5ed	1800	19.16	54.25	43.65
	1978		36.68	31.66
BS5GBLD	1800	9.43	29.44	21.62
	1978		22.97	17.89
BS6GBL	1800	12.46	34.33	27.09
	1978		26.73	22.19

Table A4: Channel Reach Parameters

ID	Reach	Lag (minutes)
R1	Black River, to mouth	398
RN1	North Branch Black River, to confluence with South Branch	924
RN2	North Branch Black River, to 111th Avenue	454
RN3a	North Branch Black River, to 116th from Upper Black River Drain	562
RN3b	North Branch Black River, to 116th from Utter Drain	194
RM0	Middle Branch Black River, to confluence with South Branch	238
RM1	Middle Branch Black River, to confluence with North Branch	71
RM2	Middle Branch Black River, to gage 04102776	533
RM3a	Middle Branch Black River, to confluence with Spicebush Creek	200
RM3b	Middle Branch Black River, to confluence with Scott Creek Drain	564
RM3c	Middle Branch Black River, to confluence with Barber Creek	225
RS1a	South Branch Black River, to confluence with North Branch	299
RS1b	South Branch Black River, to confluence with Butternut Creek	809
RS2	South Branch Black River, to confluence with Cedar Creek	247
RS3	South Branch Black River, to gage 04102700	788
RS4	South Branch Black River, to confluence with Maple Creek	738
RS5	South Branch Black River, to confluence with Great Bear Lake Drain	380